

Results of the Interaction of Mercury with Alloys of other Metals.

By J. W. MALLET, F.R.S., University of Virginia.

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It is well known that alloying metals with each other often modifies in a remarkable way their several relations to acids and other non-metallic reagents. Examples of this are afforded by the addition of silver to platinum, rendering the latter soluble, along with the former, in nitric acid—by the great resistance to the action of *aqua regia* on platinum when alloyed with rhodium or iridium—and by the solubility in cold, somewhat dilute sulphuric acid, of copper in alloy with nickel and zinc as common “German silver.”

It seemed interesting to see what the behaviour of fluid metallic mercury would be in relation to alloys of metals solid at common temperatures. For instance, if an alloy of two metals—one of them when alone amalgamating readily with mercury and the other not—should be exposed to the action of mercury, would the former resist amalgamation or the latter be rendered amalgamable, or would each continue to behave as though the other were absent and the mercury take up the one and leave the other intact?

Some experiments of this kind, recently made, seem worth recording, as little or nothing bearing upon the question appears in the principal handbooks of chemistry.

It suggested itself first to examine the case of an alloy of two metals presenting evidence of chemical combination between them, not merely of solid solution. Such a case is that of the alloy of tin and platinum which is produced by fusing the two together, the act of union being attended with sudden and very great elevation of temperature, exhibiting brilliant incandescence, and the product being found to have completely changed in respect to cohesion, the two thoroughly malleable metals giving rise to a highly brittle alloy easily crushed to powder.

Tin-platinum Alloy.

For about 5 grammes of platinum in the form of rather thick foil a piece of pure tin was weighed off representing a trifling excess over the quantity needed for two atoms of tin to one of platinum, this excess being intended to allow for a slight loss of tin by oxidation. The tin was closely wrapped in the platinum foil, and the whole was rapidly heated by a blast-lamp flame.

Complete fusion took place in a moment, with vivid incandescence. The button of alloy, after cooling, was moderately hard, very brittle, and easily reduced to powder in an iron mortar. It contained: platinum, 45.26 per cent.; tin, 54.74 per cent.

The specific gravity of the button, taken before crushing, was found to be but 10.72, notably below the calculated value, so that if there were no cavities—none were observed on crushing—there must have been considerable expansion in the act of union of the metals.

The finely pulverised alloy, with about five times its weight of pure mercury, was at once placed in a stoppered glass cylinder, and the vessel was vigorously shaken from time to time for several days. No sign of amalgamation appeared. The larger part of the mercury was run off from the seemingly quite unaltered powder, carefully freed from any trace of the latter by skimming, and distilled at a temperature a little below the boiling point in a hard glass tube, sweeping away the vapour by a current of air produced by a jet pump. No visible residue was left, so that the tin had been completely protected by the platinum from amalgamation, and neither metal had gone into solution. The surface of the particles of the original alloy powder showed under the microscope no sign of adhering mercury.

On treating this unaltered powder of the platinum-tin alloy with another portion of mercury to which a very little metallic sodium had been added, amalgamation took place at once, and the amalgam began to adhere to the surface of the glass vessel. The soft amalgam thus formed seemed to contain entangled in it the larger part of the powder, but very little was present in true solution, as on straining off the fluid portion through chamois leather and distilling, only a trifling residue was obtained, containing but a few milligrammes of platinum and tin. The main mass of the buttery amalgam left behind on straining through the leather was treated with moderately diluted nitric acid until all action ceased. It left undissolved pulverulent grey platinum, and a heavy, finely granular residue, of crystalline appearance under the microscope, greyish white and with metallic lustre. This latter was an alloy of platinum and tin which, like the bulk of the original fused alloy, was not acted upon by mercury. Heated in a stream of dry chlorine gas, it gave off tin as chloride and left metallic platinum, weighings showing the composition to be: platinum, 48.08 per cent.; tin, 51.92 per cent.; agreeing pretty well with the not very probable formula Pt_4Sn_7 , which requires platinum, 48.33 per cent.; tin, 51.67 per cent. It is by no means certain that this material was homogeneous.

It would seem that even in an amalgam which as a whole is liquid and

mobile, the mass may be viewed as consisting of a solid part or phase—the solid metal moistened by mercury—and a liquid part or phase—mercury holding the solid metal in solution—these parts mechanically separable by straining, or often simply by gravity on standing at rest. In the material just referred to nearly all of the tin and platinum seems to have existed in the former of these states.

Silver-platinum Alloy.

Platinum as heavy foil and pure silver ("proof silver" of the United States Mint) were weighed off in proportions representing four atoms of silver and one of platinum, and fused together in an assay crucible at a temperature high enough to render the alloy perfectly fluid. The ingot which was somewhat hard, but quite malleable, was rolled out to strips not more than about a tenth of a millimetre in thickness. These strips weighing about 12 grammes, were cut up into small bits, washed well with ether to remove any traces of oil from the rolls, dried, put into a stoppered glass cylinder, and shaken with about five times their weight of pure mercury, the vigorous shaking being repeated at intervals for several days. The mercury began almost at once to wet the surface of the solid alloy, and after a few hours practically all running mercury had been soaked up and the strips began to crumble. About half as much more mercury was added, and in three or four days an apparently smooth buttery amalgam had been formed.

Almost from the first the amalgam began to adhere with remarkable firmness to the surface of the glass, and before long the whole interior surface of the cylinder was coated with a mirror-like deposit as perfect as that usually obtained by means of silver reduced by aldehyde or Rochelle salt, and remarkably persistent.

The perfectly smooth buttery amalgam, containing no visibly solid fragments of the strips of alloy, was strained by squeezing through chamois leather.

The solid part which was left behind hardened somewhat on standing, but not nearly as much as amalgam of silver alone, and showed some tendency to crumble. Applied to the surface of clean platinum foil it at once produced amalgamation of the latter.

A specimen of simple silver amalgam was strained through chamois leather, and the pasty solid residue was in like manner applied to the surface of clean platinum foil. At first, even with rubbing, no sign of amalgamation of the foil appeared, but on leaving the lump of silver amalgam resting on the surface for an hour or two and then sliding it to one side, a mark was

left showing where the amalgam had lain, and after 24 hours there was distinct amalgamation of the surface. This increase of adhesiveness given to mercury by the presence of silver displays an interesting additional bit of parallelism between silver and the alkaline metals. Removing the lump of amalgam and rubbing the surface of the platinum foil vigorously with a cloth, there was left a visible stain, which changed somewhat in lustre but did not disappear on heating to low redness, showing that silver as well as mercury had adhered to the surface. Whether this silver had been carried down into the platinum by the amalgamation (as is most probable) or was partially alloyed with it by the heating to drive off mercury, the stain did not entirely disappear on treatment with nitric acid.

About 30 grammes of the fluid part of the amalgam from the silver-platinum alloy, which had been strained through chamois leather, was carefully distilled in a stream of air, keeping somewhat below the boiling point to avoid any mechanical loss by spattering, and left behind 60 milligrammes of solid residue. This was "parted" by repeated boiling with concentrated sulphuric acid. The results of the parting show the following comparison between the composition of the original silver-platinum alloy and of this portion of it which had been taken into solution by the mercury :—

| | Original alloy. | Dissolved by mercury. |
|----------------|--------------------|--------------------------|
| Platinum | 31·09 | 18·78 |
| Silver..... | 68·91 | 81·22 |

It thus appears that, unlike the case of the tin-platinum alloy, in which the platinum prevented the tin being amalgamated, in the silver-platinum alloy the silver brings about solution of the platinum by mercury, although in smaller proportion than that in which it was present in the original alloy.

Copper-tin Alloy.

It seemed desirable, in the third place, to see what effect, if any, upon amalgamation would be produced by alloying two metals, each of which is by itself readily taken up by mercury; and such metals were selected as we have reason to believe, from the experiments of Sir William Ramsay and others, are simply dissolved by mercury, and in the condition of monatomic molecules.

With this in view, a specimen of good speculum metal, made with two parts of copper and one of tin, and hence near Cu_2Sn in composition, extremely brittle, was reduced to very fine powder in an iron mortar; 10 grammes of this was placed in a stoppered glass cylinder, about five times as much pure

mercury added, and the whole well shaken at intervals for several days. At first there was no sign of amalgamation, but in a few hours this began to appear, and at the end of 24 hours the greater part of the solid alloy had been taken up by the mercury. There was no adhesion of amalgam to the surface of the glass. About half as much more mercury was added, and after four or five days, with many shakings, there remained but a very little solid alloy in powder. This was carefully removed from the surface of the seemingly smooth, buttery, or thickly fluid amalgam, and the latter squeezed in chamois leather. Forty or fifty grammes of the fluid portion which had passed through the pores of the leather was carefully distilled, guarding against spattering. It left but 2 or 3 milligrammes of solid residue, in which both copper and tin were present, the former probably in rather larger proportion than in the original alloy, but the quantity of residue was too small for an accurate analysis.

The pasty amalgam which was retained by the leather showed a strong tendency to crumble, and when examined with the microscope showed numerous particles of the solid speculum metal which had not fully blended with the mercury.

It is evident, therefore, that alloying these two metals—copper and tin—together, greatly diminishes the readiness and extent with which they unite with mercury when they are separately exposed to its action.

On the whole, these experiments show that the relations of mercury to alloys are not the same—at any rate for those tried—as to the component metals taken separately.

Many other experiments of the general nature of those now recorded suggest themselves as worth trying. Thus it would be well to examine the behaviour towards mercury of solid alloys, including one of the alkaline metals, the amalgams of which are so peculiar in character, to try the effect of mercury upon two or more alloys of the same metal in widely different proportions, and to extend such experiments to more complex alloys containing three, four, or a larger number of solid metals.
